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TITLE: Homopolar disk type eddy current dynamometer

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EUR-CL_(EPC): H02K049/04
US-CL-CURRENT: 310/178

ABSTRACT:
A disc type eddy current dynamometer (10) has a right circular rotor (11) and teeth (18a, 18b) formed in the stators (12a, 12b) such that a homopolar magnetic field within the 15a stators (12a, 12b) is formed into concentrated zones adjacent to the rotor surfaces (20a,20b). The heat produced by the generation of eddy currents in the rotor surfaces is carried away by a cooling liquid flowing from inlets (13a,13b) adjacent to the inner diameter of the rotor (11) to outlets (15a,15b) adjacent to the outer diameter of the rotor (11).

The teeth may be integral with the frame and filled with resin, or, in order to plate this surface, the teeth and non-magnetic metal filler are fabricated separately as a disc which is then plated and installed.

<IMAGE>

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U1S 2172 H2A

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US 3624435

(58) Field of search
H2A
Selected US specifications from IPC sub-classes H02K G01L

(54) **Homopolar disk type eddy current dynamometer**

(57) A disc type eddy current dynamometer (10) has a right circular rotor (11) and teeth (18a, 18b) formed in the stators (12a, 12b) such that a homopolar magnetic field within the stators (12a, 12b) is formed into concentrated zones adjacent to the rotor surfaces (20a, 20b). The heat produced by the generation of eddy currents in the rotor surfaces is carried away by a cooling liquid flowing from inlets (13a, 13b) adjacent to the inner diameter of the rotor (11) to outlets (15a, 15b) adjacent to the outer diameter of the rotor (11).

The teeth may be integral with the frame and filled with resin, or, in order to plate this surface, the teeth and non-magnetic metal filler are fabricated separately as a disc which is then plated and installed.

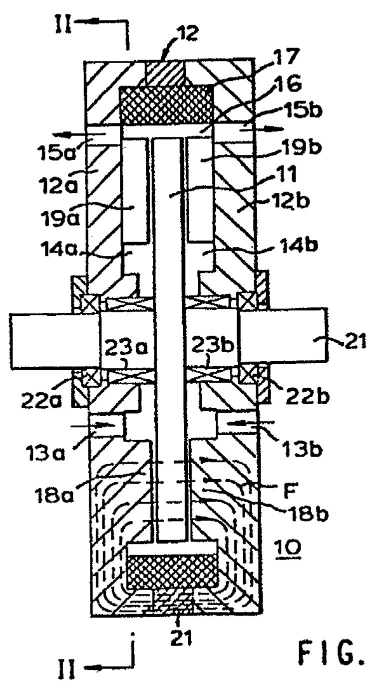

FIG. 1.

GB 2 176 944 A

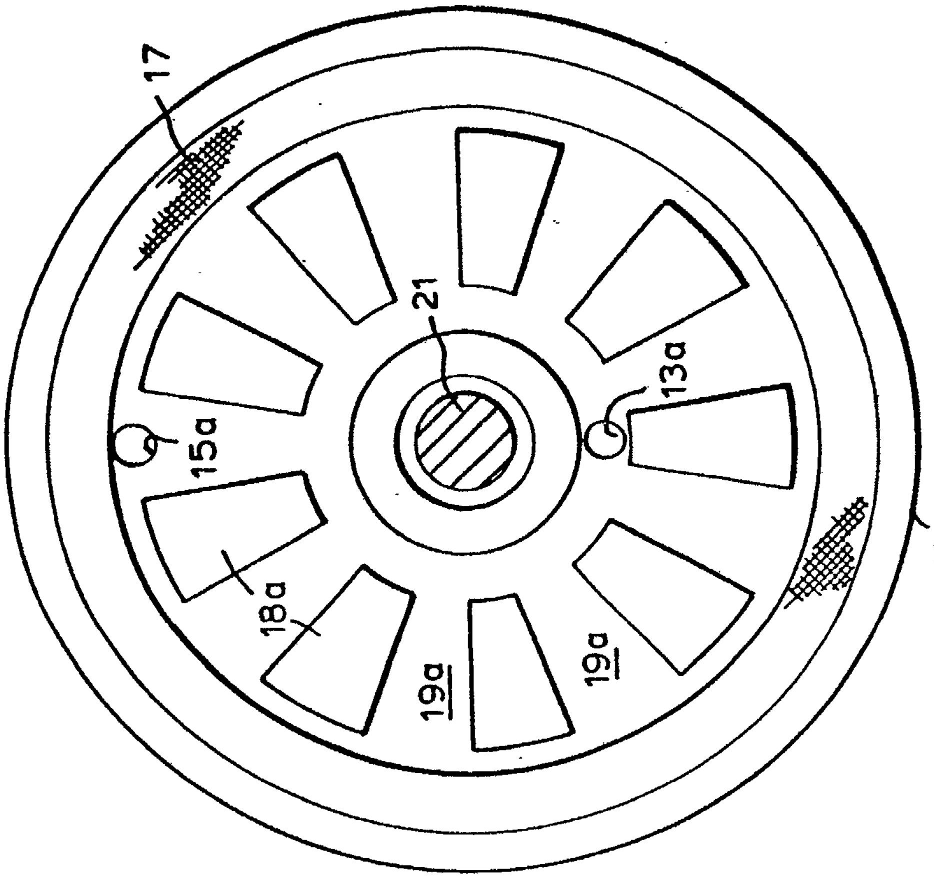
17
21
13a
15a
18a
19a
19a
12a

FIG.2.

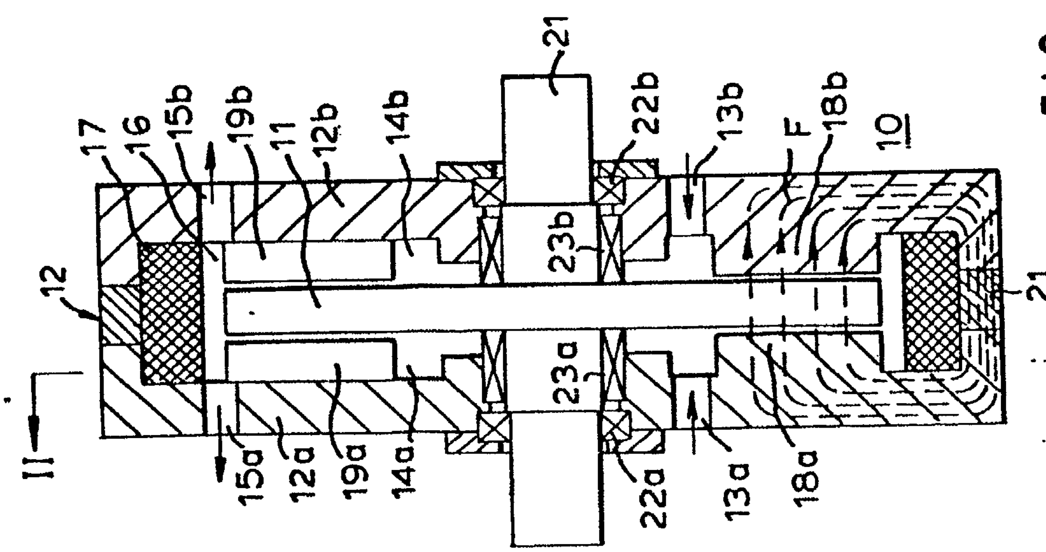
12
17
16
15b
19b
11
12b
14b
21
22b
13b
F
18b
10
23b
23a
21
II
II
15a
12a
19a
14a
22a
13a
18a

FIG.1.

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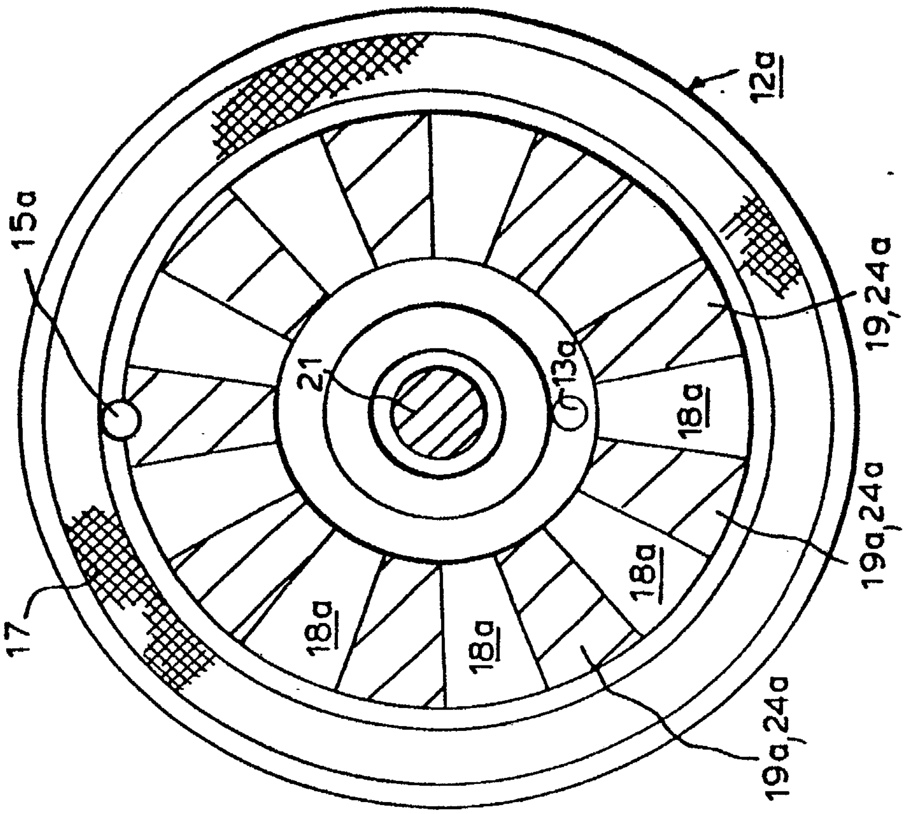


FIG. 4.

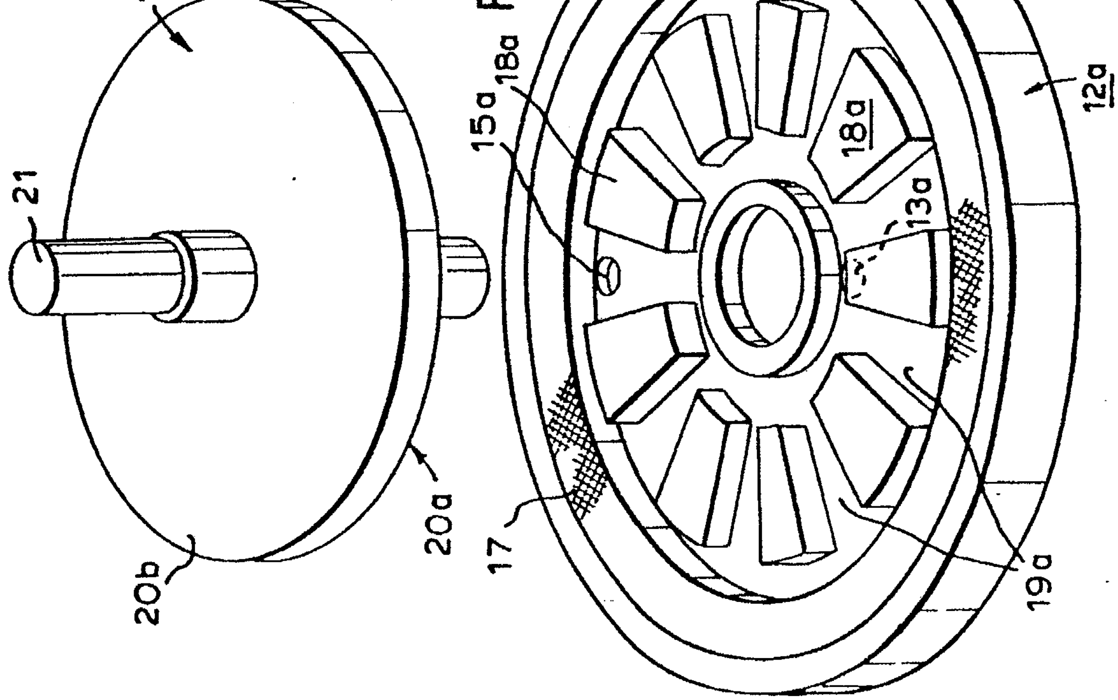


FIG. 3.

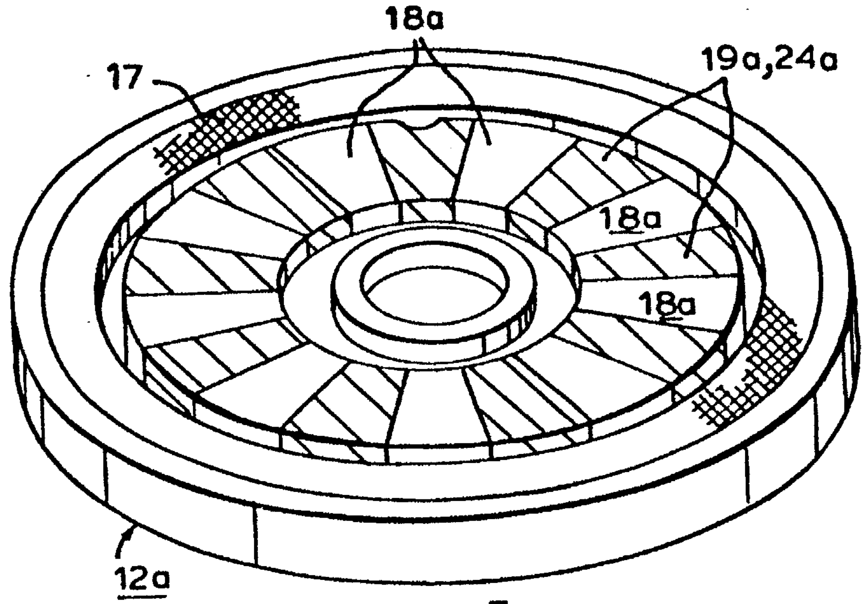


FIG.5.

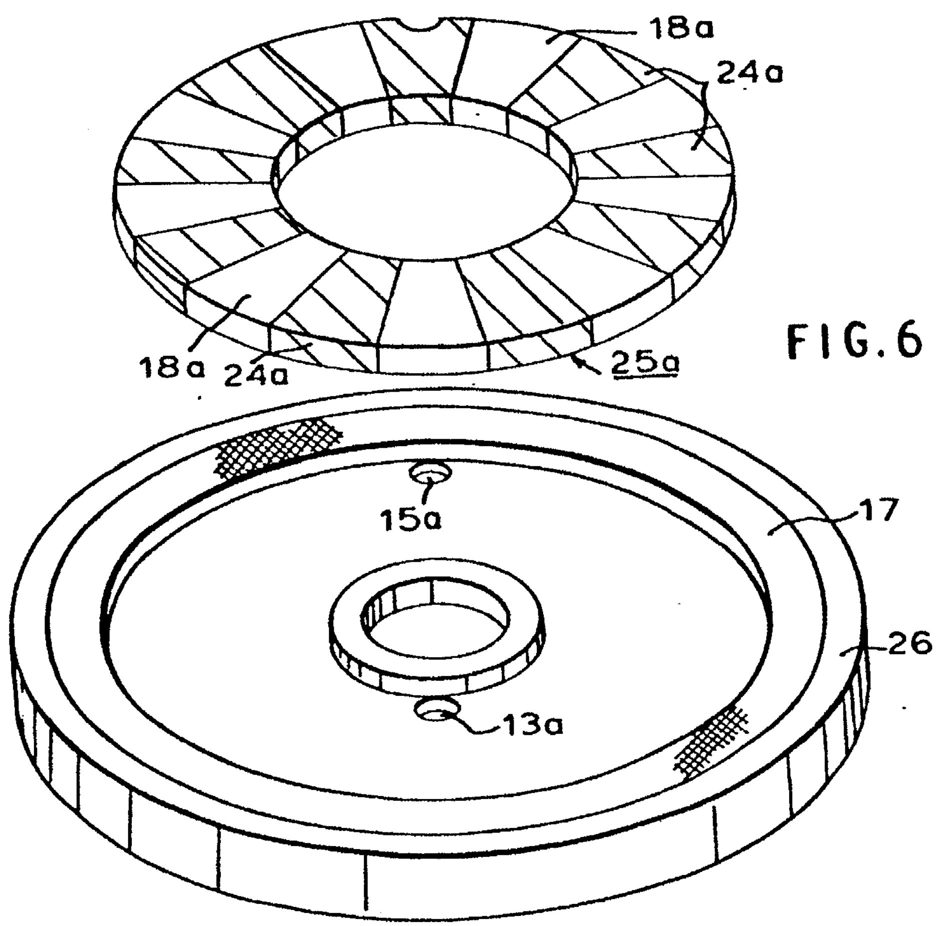
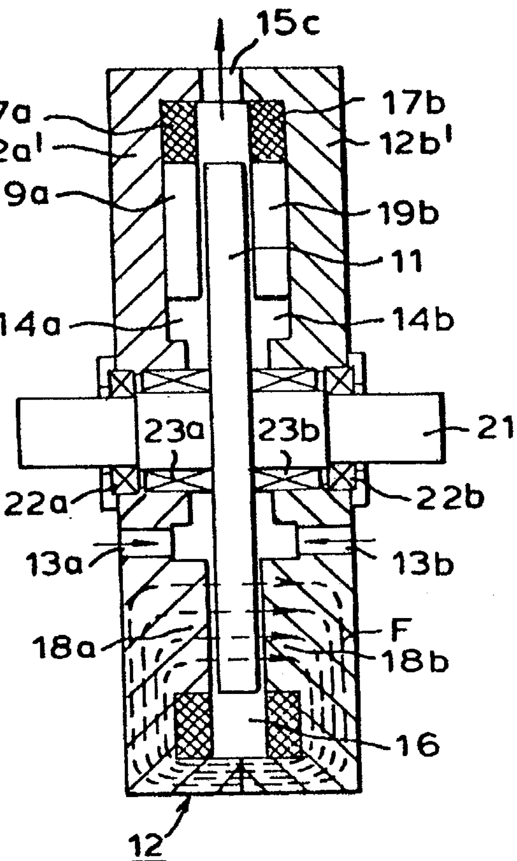


FIG.6.



15c
17a
17b
12a'
12b'
19a
19b
11
14a
14b
23a
23b
21
22a
22b
13a
13b
F
18a
18b
16
12

FIG. 7.

SPECIFICATION

Rotary electrical machines

This invention relates to rotary electrical machines, and is especially concerned to facilitate the cooling of eddy-current dynamometers having disc rotors.

Known eddy-current dynamometers using disc rotors are of two types:

The first type comprises a "toothed" disc rotor between two untoothed or plain stator parts which incorporate one or two field coils to produce a unidirectional (i.e homopolar) magnetic field within the stator and rotor. The variation in the magnetic field, necessary to generate eddy-currents and thereby the retarding torque between the rotor and stator, is produced by the variation in the magnetic permeance between the steel teeth on the rotor and the gaps between them. Eddy currents are generated within the surfaces of the stator parts, which are indirectly cooled by liquid flowing in grooves cut in their rear faces.

This type of construction has the advantage of a very simple mechanical and electromagnetic construction but because the 'loss surfaces' (where eddy currents are generated) are indirectly cooled there is considerable heat transfer into the field coils and shaft bearings rather than into the cooling liquid. Direct cooling of the loss surfaces is not used because of the high minimum torque capacity produced by a toothed rotor running in a liquid and the problems with cavitation damage to the rotor teeth.

The second type comprises a right circular disc rotor between two stator parts which incorporate a number of electromagnets arranged to give an alternating magnetic field around the axial faces of the rotor. Because the electromagnets must be wired so that current flowing through them produces a magnetic field which is of opposite sense in adjacent electromagnets, this type of construction is called 'Salient pole'. Eddy currents are generated within the axial faces of the rotor, which is directly cooled by liquid flowing over these faces.

Because the 'loss surfaces' are directly cooled, there is very little heat transfer into the electromagnet coils or the shaft bearings and a right circular disc rotor running in a liquid does not have as high a minimum torque capacity as a toothed rotor, and is less prone to cavitation damage. However, as the variation in the magnetic field must be produced by a number of electromagnets (typically twelve or sixteen in total) a Salient pole machine is complicated.

According to the present invention there is provided a rotary electrical machine in which heat is generated due to electrical eddy currents when mechanically driven, the machine comprising a rotor and a stator, the rotor being in the form of a right circular disc having a central axis of rotation and of which the magnetic reluctance and electrical resistance is uniform from place to place around its axis, the stator comprising field coil means and homopolar magnetic circuit means for generating at least one magnetic field passing through the rotor and being such that the polarity of the magnetic field passing through the rotor is the same everywhere around the axis of rotation but varies in magnitude from place to place around the axis, so that eddy currents are generated in the rotor on rotation relatively to the stator, due to non-uniformity of the magnetic reluctance of the magnetic circuit means.

The invention will be described by way of example with reference to the accompanying drawings, wherein:-

Figure 1 is a sectioned side elevation of a directly liquid-cooled, homopolar, eddy-current dynamometer embodying the invention;

Figure 2 is a section on line II-II in Figure 1;

Figure 3 is an exploded perspective view of the rotor and part of the stator of the machine of Figures 1 and 2;

Figure 4 is a view, corresponding to Figure 2, of a modified machine;

Figure 5 is a perspective view of the stator of the Figure 4 machine;

Figure 6 is an exploded perspective view of parts (before assembly) of the stator of a further modified machine; and

Figure 7 is a view, corresponding to Figure 1, of a still further modified machine.

Like numerals refer to like parts throughout.

Referring to Figures 1 to 3, a liquid-cooled eddy-current dynamometer 10, which is a particular type of rotary electrical machine in which heat is generated due to electrical eddy currents when mechanically driven, comprises a rotor 11 which is a right circular disc, magnetically and electrically homogeneous and made of a material with low electrical resistivity and high magnetic permeability. The rotor 11 is arranged to rotate between two electrically magnetisable stator parts 12a, 12b, which are separated by a spacer ring 12c, of a stator 12.

The stator parts 12a, 12b, which may be cast or profile-burnt or made from laminated steel, and which should be made from a material with a high magnetic permeability, are provided with inlets 13a, 13b for the cooling liquid, which fills annular chambers 14a, 14b, one on each side of the rotor 11, and flows out of the stator parts 12a, 12b through outlets 15a, 15b near the top of the machine. In fact, the cooling liquid entirely fills the free space within the machine, including an outer annular space 16 around the outer periphery of the rotor 11.

In the stator is formed an annular space wherein a magnetic field coil 17 is situated. The magnetic field coil 17, in combination with the rotor 11 and stator 12, generates a generally toroidal homopolar magnetic field F such that the polarity of the field passing through the rotor is the same (conventionally represented as from left to right in Figure 1) everywhere around the axis of rotation, but the magnitude varies from place to place around the axis due to non-uniformity of the magnetic reluctance of the magnetic circuit. To this end, in each of the stator parts 12a, 12b are formed 'teeth' 18a, 18b (not sectioned in Figure 2) separated by 'gaps' 19a, 19b. These teeth 18a, 18b cause the magnetic field produced by the field coil 17 to be formed into concentrated zones, the 'gaps' 19a, 19b being deep enough to prevent very much of the magnetic field from passing across them.

The teeth 18a, 18b may either be integral with the main bodies of stator parts 12a, 12b respectively, or separately machined and then securely fixed in place.

In a modification, shown in Figures 4 and 5, the gaps 19a, 19b, instead of being left empty, are filed with a suitable non magnetic filler 24a, 24b (shown sectioned or 'hatched') to create a smooth stator surface on each side of the rotor 11 so as to keep the cooling water in contact with the rotor surfaces 20a, 20b.

The rotor 11 is fixed on a shaft 21 which runs in bearings 22a, 22b, between which are cooling fluid shaft seal assemblies 23a, 23b which provide seals between the shaft 21 and the stator 12 and in particular keep the cooling fluid away from the bearings 22a, 22b.

As the rotor 11 rotates, any particular section of the rotor 11 will experience first a high magnetic field and then a low magnetic field as it passes teeth 18a, 18b and then gaps 19a, 19b - each tooth 18a may be, but need not be, in registry with a corresponding tooth 18b and likewise, each gap 19a may be, but need not be, in registry with a corresponding gap 19b. The rotor 11 therefore experiences a varying magnetic field which induces eddy currents in or near to the two surfaces 20a, 20b of the rotor 11. The eddy-current themselves produce fields which act in such a way as to try to prevent the variation in the magnetic field experienced by the rotor as it passes the teeth 18a, 18b and the gaps 19a, 19b. This produces a torque reaction between the rotor 11 and the stator 12, measurable by means of a suitable torque measuring system (not shown).

The eddy currents also produce resistive heating in the rotor surfaces 20a, 20b and this heat is carried away by the cooling liquid flowing over the rotor surfaces 20a, 20b.

Figure 6 illustrates another arrangement in which the teeth 18*a* and filler material 23a are fabricated of plateable materials into a disc 25a which, after being plated is securely fixed into the stator casing 25a of stator part 12a (the stator 12b being similarly fabricated).

Figure 7 illustrates a modification in which the spacer ring 12c is omitted - the stator parts 12a' and 12b' being extended axially accordingly - the coil 17 is replaced by two half coils 17a, 17b one in each stator part 12a, 12b, and the two outlets 15a, 15b are replaced by a single radial outlet 15c at the very top of stator 12, the cooling fluid exiting between the two half coils 17a, 17b.

CLAIMS

1. A rotary electrical machine in which heat is generated due to electrical eddy currents when mechanically driven, the machine comprising a rotor and a stator, the rotor being in the form of a right circular disc having a central axis of rotation and of which the magnetic reluctance and electrical resistance is uniform from place to place around its axis, the stator comprising field coil means and hompolar magnetic circuit means for generating at least one magnetic field passing through the rotor and being such that the polarity of the magnetic field passing through the rotor is the same everywhere around the axis of rotation but varies in magnitude from place to place around the axis, so that eddy currents are generated in the rotor on rotation relatively to the stator, due to non-uniformity of the magnetic reluctance of the magnetic circuit means.

2. A machine as claimed in claim 1 wherein the magnetic circuit means of the stator comprises angularly spaced-apart teeth of magnetic material arranged around the axis of the rotor.

3. A machine as claimed in claim 2 wherein non-magnetic material fills spaces between the teeth and the stator is provided with a smooth disk-like surface adjacent the rotor.

4. A machine as claimed in claim 3 wherein at least some of the teeth and the space-filling non-magnetic material are farbicated as a disc separately from other parts of the magnetic circuit means and after such fabrication are incorporated in the stator.

5. A machine as claimed in claim 4 wherein the last-mentioned disc is plated.

6. A machine as claimed in claim 2 or 3 wherein the teeth are integral with other parts of the magnetic circuit means.

7. A machine as claimed in any preceding claim wherein the rotor is directly liquid-cooled by cooling liquid flowing thereover.

8. A rotary electrical machine or dynamometer substantially as described with reference to and as illustrated in Figures 1 to 3 of the accompanying drawings.

9. A rotary electrical machine or dynamometer substantially as described with reference to and as illustrated in Figures 1 to 3 modified as in Figures 4 and 5 of the accompanying drawings.

10. A rotary electrical machine or dynamometer substantially as described with reference to and as illustrated in Figures 1 to 3 modified as in Figure 6 of the accompanying drawings.

11. A rotary electrical machine or dynamometer substantially as described with reference to and as illustrated in Figures 1 to 3 modified as in Figure 7 of the accompanying drawings.

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